Techno-Pedagogy for Promoting Problem Solving Ability and Scientific Creativity among Secondary School Students

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Abstract

Information and Communication Technology (ICT) is making a revolution in the teaching-learning process. Techno-pedagogy is the art of incorporating technology into the teaching-learning process. This study aimed to examine the effectiveness of techno-pedagogy on secondary school students' problem solving ability and scientific creativity. The study comprised post-test non-equivalent experimental control group design using a sample of 60 students. The major findings revealed that the students, who learned through techno-pedagogy, enhanced their problem solving ability and scientific creativity. The results have great educational implications for using techno-pedagogy in teaching-learning process at the secondary level. The findings of the research motivate teachers to rethink their teaching strategies, and redefine their approaches to teaching and learning.

Introduction

The twenty-first century envisioned a paradigm shift in the realm of teaching-learning process, from the transmission of knowledge to the construction of knowledge. The twenty-first century also witnessed an explosion of knowledge in the field of Information Technology (IT). Information and Communication Technology (ICT) is the buzzword of this century where the attainment of

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adequate knowledge and necessary skills are important factors to make an individual successful in his life. The technological revolution steered changes in all spheres including education.

The use of ICT in teaching and learning is essential to tap the inner potential of the child. Techno-pedagogy is the need of the hour to help the child to develop their potential to the optimum level. Techno-pedagogy is becoming a revolution in the realm of the teaching and learning process. Techno-pedagogy makes learning pleasurable and enables the students to explore deeper into the domains of knowledge.

Theoretical Overview of Variables

Techno-Pedagogy

Techno-pedagogy is the integration of technology in the teaching-learning process. The approaches of technology integration in education confronted a paradigm shift from techno-centric approach to techno-pedagogic approach. The techno-centric approach emphasised on technology, and focused on the skills and knowledge to use technology in classroom while on the other hand the techno-pedagogy is based on the pedagogy, and emphasis is both on technology and pedagogy. The techno-pedagogy refers to the use of technology in teaching-learning process. Or in other words, it is the integration of technology in the classroom. When technology is integrated in the teaching-learning process, it not only makes learning experience enjoyable for students but also, helps in retention of information. In techno-pedagogy, there is a harmonious union of technology, content and pedagogy. The technology includes modern technologies such as computer, internet and its resources. Pedagogy is the art and science of teaching. It deals with how effectively a subject knowledge is transacted to the students. The content refers to the subject or topic to be taught to the students. So, in techno-pedagogy the teacher integrates the technological knowledge with the pedagogical knowledge and the content is transacted in an effective way. Technological Pedagogical Content Knowledge (TPACK) is one of techno-pedagogical integration approaches in the field of technology integration. The techno-pedagogical integration also witnessed dramatic changes and TPACK is one of the most effective integrations in the teaching-learning process. TPACK refers to how effectively one can teach with the help of technology. In TPACK an attempt is made to teach effectively with technology which requires effective presentation of concept with suitable technology. It emphasises coordinating subject specific activities using emerging technologies to enhance learning in the classroom (Cox and Graham, 2009).

Problem Solving Ability

Thomas J. D'Zurilla (1988) defined problem solving as a "cognitive-affective-behavioural process through which an individual (or group) attempts to identify, discover, or invent effective means of coping with problems encountered in everyday living". This process includes "problem analysis, shaping the problem, generating alternative strategies, implementation and verification of the selected solution. The distinguishing feature of a problem is that there is a goal to be reached and how you get there depends upon problem orientation (problem-solving coping style and skills) and systematic analysis" (Robertson, 2001). The problem solving cycle is represented in Fig. 1.

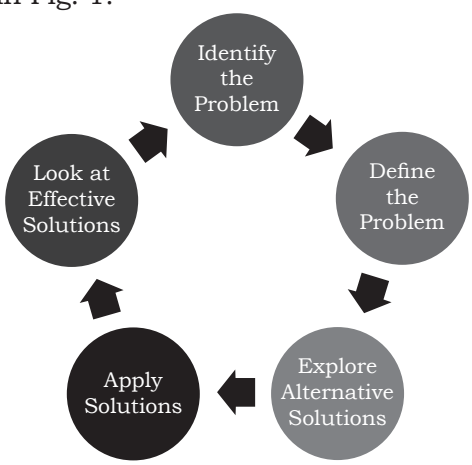


Fig. 1: Problem solving cycle

**Source: Bransford, J. and Stein, B.S. 1984. The Ideal Problem Solver: A Guide for Improving Thinking, Learning, and Creativity. New York.*

Scientific Creativity

Torrance, (1962) defined creativity "as an activity resulting in new products of a definite social value. Creativity is defined as the tendency to generate or recognise ideas, alternatives, or possibilities that may be useful in solving problems, communicating with others, and entertaining ourselves and others". Scientific creativity deals with unusual and original excellence in the field of science and

In 1962, Torrance conceptualised 'scientific creativity' as a "process of becoming sensitive to problems related to science, deficiencies, gaps, missing elements, disharmonies, identifying the difficulty searching for solutions, testing and retesting of these hypotheses in science, and possibly modifying and retesting them, and finally communicating the results". According to Lacklen, "scientific creativity is creative thinking through the media of science. It is a multidimensional attribute, differentially distributed among people, and chiefly includes such factors as fluency, flexibility, originality, and inquisitiveness" (Lacklen, 1964).

In India, V.P. Sharma and J.P. Shukla (1985) conceptualised 'scientific creativity' "as a process-oriented concept measuring the extent of scientific temper and talent on common contents of science and technology." 'Scientific creativity' may be considered as specific creative expression, unique

production, and divergent thinking in science and technology. It may be a unique scientific process responsible for novel scientific excellence, and accomplishments in science and technology (Sharma and Shukla 1985).

Review of Related Studies

A. Shabana (2022) conducted an experimental study to examine the effectiveness of techno-pedagogy on coping strategy, study habits and academic performance of *madarsa* students. The result reported that the techno-pedagogical approach enhanced the study habits, coping strategies and academic performance of *madarsa* students. The component wise analysis of variables—study habits and coping strategies showed statistically significant difference between students in the experimental, and control group.

Quillo and Rondina (2021) carried out a study to find out the effectiveness of techno-pedagogy on enhancing the academic achievement in mathematics using pre-test and post-test quasi experimental design. The sample comprised of 18 sections of Grade X Mathematics students in which control group consisted of nine sections having 343 students and experimental group with nine sections of 388 students. The main findings revealed that the students who were exposed to techno-pedagogy enhanced the scores on Mathematics achievement than those who were not exposed.

Baregama and Rita (2021) reviewed the researches on techno-pedagogy. The result revealed that academic performance is enhanced by using techno-pedagogy. Moreover, techno-pedagogy enhanced other variables like interest, motivation and creativity. The study enlisted the challenged faced while using ICT in classroom and the suggested ways to improve the present condition.

Yildirim and Sensoy (2018) carried out an experimental study to know the effect of technological practices on Science course attitude levels Grade VII students in Turkey. The sample comprised 78 students, having 36 students in experimental and 38 students in control group. The tool used for the study was attitude scale towards Science course. The experimental design adopted was pre-post and follow-up. The results showed that the students in experimental group possess high level of attitude towards Science course than control group.

Sarkar, Sundarakrishnan and Mohapatra, (2015) conducted a study on the effect of techno-pedagogy programme on achievement in Science, Mathematics and Geography. The investigator selected 10 Middle schools and randomly selected 20 teachers for the study. The teachers are trained through the techno-pedagogy programme. The duration of the study was 12 months, and it continuously observed students and their performance in Science, Geography and Mathematics. The results revealed that the students taught by those teachers who got training in techno-pedagogy, used techno-pedagogy effectively in

classroom, and the students scored higher in Science, Mathematics and Geography than those in control group.

Baranisree (2012) developed a video-based programme on English grammar and tested its effectiveness on a sample of 100 secondary school students. The result showed that the academic achievement of the students taught through the video programme proved to be higher than that of the traditional method.

Ishan (2011) conducted a study on 'Multi Media-Based Instructional Technology on African American Ninth Grade Students' Mastery of Algebra Concepts'. Quasi experimental design was used for the study. The results showed that urban African American students lack abstract understanding of algebra and were below their academic level in comparison to other ethnic groups.

Babu and Vimala (2008) carried out a study on the multimedia approach in accountancy learning at the higher secondary level. The result revealed that there was no significant difference between the pre-test and post-test scores of the experimental group of aided school students to the remediation through multimedia. The multimedia approach played a positive role in minimising the errors in accountancy learning at the higher secondary level.

Bala and Shaafiu, Quraish (2016) conducted a study on secondary school students' problem solving ability and examination anxiety. The research used descriptive method and the sample comprised a total of 200 secondary school students having 100 males and 100 females. Examination anxiety scale, problem solving ability scale and previous years mark were used as tools for collecting data from 10 secondary schools in the Maldives. The study concluded that there exists no significant difference between male and female students in academic achievement, problem solving ability, and examination anxiety. The correlation of variables revealed that there exists a positive correlation between academic achievement and problem solving ability but a negative correlation between examination anxiety, and academic achievement.

Anboucarassy, (2015) carried out a study on problem solving ability of 300 higher secondary students in relation to their learning styles. Investigator used standardised tools, problem solving ability test and styles of learning and thinking to collect data. The result revealed that problem solving ability of higher secondary students is average in nature. The study observed that there is a gender difference in the problem solving ability. But there is no significant difference between the students of rural and urban, government and private, and Arts and Science stream in their problem solving ability, and a positive relationship between problem solving ability and learning.

Hu et.al., (2013) conducted a study on the effectiveness of a learning intervention programme on the scientific creativity of secondary

school students. They developed an intervention programme 'Learn to Think' (LTT) for raising abilities of primary and secondary school students. It was implemented in more than 300 schools, and more than 200,000 students took part in the experiment over 10 years. The results indicated that LTT influenced students' creative thinking ability directly through the process of teaching students thinking methods. The LTT is designed with some special activities to train creative thinking for enhancing students' creative thinking ability. The LTT has shown its positive effect on students' thinking ability (Hu and Zhang, 2009), the creative tendency (Li, 2010), creativity (Hu and Yun, 2006), and creative personality (Wu, 2009) and it promoted the development of scientific creativity of secondary school students, and the effects on the scientific creativity were not necessarily immediate but tended to be long-lasting.

There are many studies conducted on techno-pedagogy in foreign countries and the top-most countries researching on techno-pedagogy were USA, followed by Turkey and Australia. The studies on techno-pedagogy are comparatively less in India. So, there is a need for conducting studies on techno-pedagogy in Indian classroom.

Need and Significance

Education ought to be structured to meet the needs of students in this twenty-first century world for that it is pertinent to address real life issues and problems which are important to society as well as to the Nation. Education has a prime role to play in creating responsible, innovative, analytical, and also compassionate citizens. The education system must respond to the changes in a society as it transforms over time. Then only, education is said to be relevant to our system. For the progress of our country, our institutions of learning must gear up for facing the challenges of a knowledge-based and technology-driven world. For this, there is a dire need for integrating technology into the classroom. Teachers can empower the students with values and skills by incorporating innovative methods in the learning process. These values can easily be inculcated by integrating techno-pedagogy in curriculum transaction.

Moreover, it is also the need of the hour to develop the problem solving ability and scientific creativity of our students for living successfully in society. So, as a teacher, it is our responsibility to develop the creativity and problem solving ability of students through teaching-learning process. In this context, a study to develop problem solving ability and instill-scientific creativity through techno-pedagogy is worthwhile, and it will create a future generation worthy enough to lead the country into progress.

Statement of Pproblem

The study is to know the effectiveness of techno-pedagogy on problem

solving ability and scientific creativity among secondary school students. As the nature of the problem was concerned, the best way was to adopt the experimental method for the study. The investigator designed a module on Science, effectively incorporating ICT appropriate to the Science content of Grade IX for the experimental phase of the study. The present study has been taken up with the following objectives.

Objectives

1. To find the effectiveness of the techno-pedagogical approach on problem solving ability of secondary school students of Bhopal.
2. To study the effectiveness of the techno-pedagogical approach on scientific creativity of secondary school students of Bhopal.
3. To suggest strategies for quality Science education using techno-pedagogy at the secondary level.

Hypotheses

1. There will be no significant difference between the experimental and control group taught through techno-pedagogy and the conventional approach respectively, on inculcating problem solving ability and scientific creativity of secondary school students.

Operational Definition of Key Terms

Investigator operationally defined the key terms used in the study. They are discussed under appropriate headings.

Techno-Pedagogy

Techno-pedagogy is the use of ICT in the teaching-learning process. Investigator prepared a module incorporating animations, pictures, and videos on the topic 'The Cell' for teaching in the experimental phase of the study. For the study, techno-pedagogy is the method of teaching the content of Science using a module prepared by the investigator, based on ICT, which included videos, pictures and animations.

Problem Solving Ability

Problem solving ability is the ability of a person to solve problems, not previously known to him with his experience and knowledge. In other words, it is the ability of an individual to use acquired knowledge, skills, and understanding to satisfy the demands of an unfamiliar situation. The individual must synthesise the knowledge and apply it to a new and different situation.

For the study, problem solving ability is the student's ability in solving problems in terms of scores obtained by the problem solving scale.

Scientific Creativity

Torrance (1962) defined creativity as, "an activity resulting in new products of a definite social value". Barron F.X. (1969) said "Scientific creativity

is the creativity in the specific field, i.e., science".

For the present study, scientific creativity stands for various aspects of divergent thinking ability in science (as defined by Guilford and his associates), estimated through its accepted characteristics, viz., measures of fluency, flexibility and originality, and it is obtained using standardised test of scientific creativity.

Methodology

An experimental design was used for the study, and adopted a quasi-experimental post-test experimental and control group design. Investigator prepared a module incorporating ICT in Science for the experimental phase of the study. The experimental study design is represented in Fig. 2.

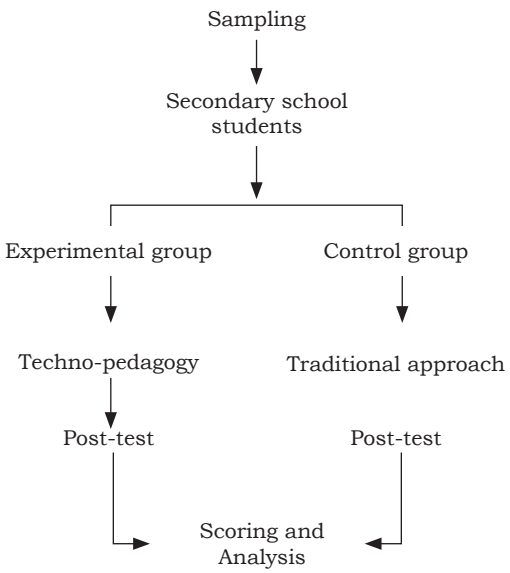


Fig. 2: Experimental study design

Sample

The sample consisted of a total of 60 secondary school students. Two separate divisions of Grade IX were randomly selected as experimental and control group. The actual sample size was 70 and the investigator deleted the incomplete answer sheets, and counted only the regular attending students to the end of the programme and the sample size was fixed at 60; having 30 students in both the experimental and control groups. The small sample size is justified for experimental research (Cohen et al., 2007).

Tools

Investigator used standardised tools for collecting data. They are described below.

Problem Solving Scale

The problem solving scale was developed and standardised by the Research Institute for Problem Solving (RIPS), University of Minnesota, USA, and the investigator translated it to Hindi and made suitable modifications appropriate to the Indian context. The problem solving scale consisted of 16 items, and the responses were distributed on 5 point scale continuum of; not at all, rarely, some times, often and very often

Verbal Test of Scientific Creativity (Sharma and Shukla, 1985).

To assess the scientific creativity, verbal test of scientific creativity developed by Sharma and Shukla (1985) was used. It consisted of 12 items, which have been classified into 4 sub-tests namely (i) consequences test (ii) unusual uses test (iii) new relationship test and (iv) just think why test. The reliability of this tool has been established using split-half method. The co-efficient was found to be 0.75. The validity co-efficient of scientific creativity was found to be 0.86.

Experimental Intervention

Developmental of Techno-Pedagogical Module

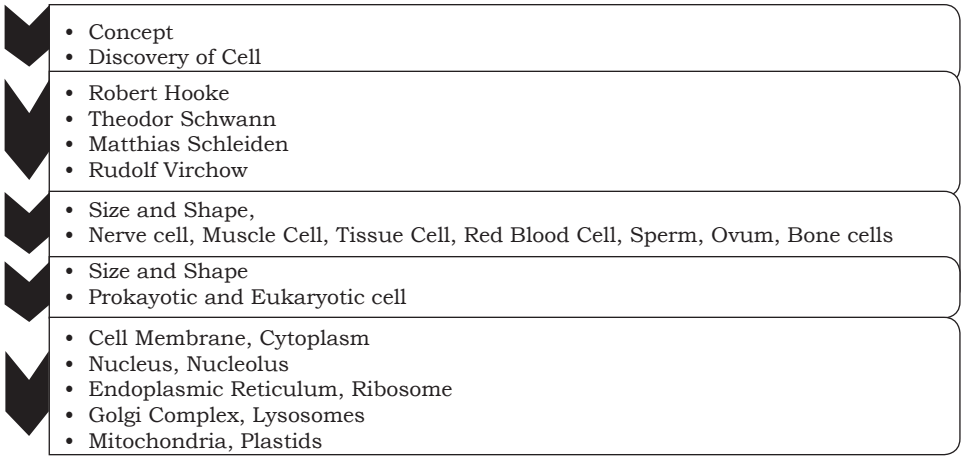
Investigator developed a techno-pedagogical module for the experimental phase of research, incorporating ICT. In developing the module, the investigator prepared Powerpoint slides on the selected topic and inserted animations, interactive videos, and pictures wherever necessary. The various sources of the internet are used for this purpose. Educational videos, expert talks, and animations are used for making the module interesting and pupil participatory.

For developing the techno-pedagogical module investigator extensively reviewed the textbook, other source books and the syllabus of the Grade IX. Investigator thoroughly analysed the biology textbook based on the NCERT syllabus and finally selected the Unit 'The Cell'. Investigator divided the Unit 'The Cell' into eight sub-units.

The investigator incorporated videos, animations, slides and interactive sessions on each sub-topic while preparing the module.

Data Collection Procedure

The investigator contacted the Principal of the M.D. Higher Secondary School, Bhopal well in advance for getting permission to conduct the experiment. Investigator selected two divisions of Grade IX randomly and allocated them to experimental and control group by tossing a coin. The total sample for the experimental study constituted 60 students, each group having 30 students. After allocating students into experimental and control groups, the two groups were given different treatments. The experimental group was taught using techno-pedagogical approach and the conventional approach was used for teaching the control group. A schedule for taking classes was fixed for both the experimental and control group. To avoid the effect of discrepancies due to teacher variation, the investigator herself taught all the lessons in both groups. After the experiment, the two groups were post-tested with problem solving scale and verbal tests of scientific creativity. The scores of these



post-tests were used for analysis of data. The scores were tabulated and analysed using SPSS version 16.

Results and Discussion

Techno-Pedagogical Effect on Problem Solving Ability

Investigator conducted an experiment for assessing the effect of the techno-pedagogical approach over the conventional approach. The duration of the experiment was 80 days. After the experiment problem solving scale was administered to both groups. Investigator tested the effectiveness of the techno-pedagogical approach over the conventional approach by comparing the experimental and control groups on the scores of problem solving ability. The scores of problem solving ability with t-values and level of significance are represented in Table 1.

Table 1 revealed that the t-value 23.853 is significant at 0.01 level, for the difference in the mean scores of problem solving ability of students of the experimental group and control group. Hence, it is inferred that the techno-pedagogical module developed by the investigator is effective in developing problem solving ability of students in the experimental group. Since the mean score of the experimental group is greater than that of the control group, it is concluded that the techno-

Table 1
Effect of Techno-pedagogical Approach on Problem Solving Ability

Category	Approach	N	Mean	SD	Df	t-value	Significance
Experimental Group	Techno-pedagogy	30	63.67	4.21	58	23.85	0.01 level
Control Group	Conventional	30	38.27	4.03			

pedagogical approach is better than the conventional approach in developing problem solving ability of students. It can be said that the experimental group is an edge over the control group in the problem solving ability. Therefore, the null hypothesis there will be no significant difference of the techno-pedagogical approach and the conventional approach on problem solving ability of secondary school students is rejected. The results are in tune with the study of Rainer et al., 2021. The researchers investigated effectiveness of Smart Personal Assistant (SPA) technology for enhancing problem soving skills of students. The result revealed that SPA technology precisely enhanced problem solving ability of students.

Techno-Pedagogical Effect on Scientific Creativity

The investigator carried out an experiment to test the effectiveness of the techno-pedagogical approach over the conventional approach on scientific creativity. After the experiment, the verbal test of scientific creativity was administered to both groups. Investigator tested the effectiveness of the techno-pedagogical approach over the conventional approach by comparing the experimental and control groups on the post-test scores of scientific creativity. The scores of scientific creativity with t-values and level of significance is represented in Table 2

Table 2 revealed that the t-value 11.475 is significant at 0.01 level for the difference in the mean scores of scientific creativity of students of the experimental group and control group. Thus, the subjects exposed to the techno-pedagogical approach achieved a significantly higher mean on scientific creativity in comparison to the conventional approach of learning. Hence, it is inferred that the developed techno-pedagogical module is effective in developing the scientific creativity of students in the experimental group.

It revealed that the experimental group was found to be superior to the control group in the scores of scientific creativity. In other words, the techno-pedagogical approach is found to be more effective in enhancing the Scientific Creativity of students at the secondary level. Therefore, the null hypothesis there will be no significant difference of the techno-pedagogical approach and conventional approach on inculcating scientific creativity

Table 2
Effect of Different Approaches of Instruction on Scientific Creativity

Category	Approach	N	Mean	SD	df	t-value	significance
Experimental Group	Techno-Pedagogy	30	28.18	70.04	58	11.475	0.01 level
Control Group	Conventional	30	13.08	17.12			

of secondary school students is rejected. The treatment with the techno-pedagogical module helped the students of the experimental group to enhance their scientific creativity. The techno-pedagogical module incorporated animations, cartoons with colourful and attractive pictures, and eye-catching videos which raised the imaginative power and the out-of-box thinking capacity of students and thus, enhanced the scientific creativity. Similar results are obtained in the research conducted by Wicaksono and Madiazim, 2017. Technology made the teaching-learning more interesting and engaging. The students interact more and build concepts in a unique way by the technology. (Wicaksono and Madiazim, 2017).

Strategies for integrating Techno-Pedagogy for Curricular Reforms in Science Education

It is essential to integrate techno-pedagogy to bring curricular reforms in Science education. Nowadays, internet gives infinite opportunities to learn and implement different technologies in the classroom. Some technologies suitable for learning Science are given for integrating technology into Science for making Science learning pleasurable and meaningful.

Science 360

This is an app created by the National Science Foundation. Science 360 can be used by teachers to support Science learning in the classroom. Science 360 contains hundreds of videos on various Science topics. One can tap on any image visible on the screen then all details are visualised interestingly. The videos also provide written descriptions, and links for related videos which make this app useful and comprehensive for Science learning. The cool 360-degree view allows kids to explore 3-D images from every angle.

My Molecularium

This is an interesting app for learning chemistry, chemistry equations, and molecular formulae. This app visualises how electron sharing takes place between molecules in an interesting manner, which makes learning interesting. The fun games in this app encourage students to easily understand and learn chemistry concepts related to molecular structure, chemical formulas, and skeletal formulas.

Virtual labs

Science learning is not complete without the experiment. But all schools don't have good labs or expensive equipment to do experiments in Science makes an obstacle to Science learning. Virtual labs are a solution to this problem, and make science learning interesting and meaningful. Virtual labs are an initiative of the Ministry of Education under the scheme Nation Mission on Education through Information and Communication

Technology (NMEICT). Virtual labs created reforms in Science learning through ICT. Virtual labs consist of 700+ web-enabled experiments. The outstanding feature of virtual labs is that they do not require any additional expenditure in terms of infrastructure as they can be accessed via the internet. The internet carries a vast range of resources of information for integrating technology in classroom. Describing all those resources are not in the scope of this article, and hence, the investigator selected some useful resources for effectively integrating technology in classrooms.

Educational Implications

This study has wide implications in the educational sector. The findings of the study can be used by educators to make a revolutionary change in all fields of teaching-learning process. Though the teachers are aware of ICT they are not capable of incorporating it effectively in the teaching-learning process. In this context, the techno-pedagogical module developed by the investigator will surely help them to mitigate the problem. Besides, the teachers can utilise the infinite resources of internet as it provides many technological solution for making Science learning interesting. The virtual labs, Science 360, My Molecularium are some examples that can be successfully used by teachers in classrooms for effective integration of technology.

The effective use of ICT in teaching and learning helps students to think critically about issues in their life, and use their decision-making and problem solving skills for taking crucial decisions with confidence. Moreover, it also helps to develop the life skills of students. No doubt, life skills can empower the students to face the challenges of both life and society. The implications for teachers are evident that this module can very well be used by teachers with their convenience in the classroom. The animations and videos used in the module not only raise the curiosity but also make learning more meaningful, participatory and interesting among students. The module can be used by teachers for the effective transaction of the content in the classroom.

Critical Reflections

This research proved that techno-pedagogy is effective in curricular transactions. But there are some impediments for using techno-pedagogy in classroom. Many schools lack basic infrastructure for using technology such as computer lab, internet connectivity, etc. Constant supply of electricity is also a luxury for many rural schools. Many of the teachers lack the skills to integrate technology into science learning. So these problems have to be addressed in a systematic way to tap the potential of techno-pedagogy.

Conclusion

The present research provides a direction for effective implementation

of ICT in teaching-learning process through techno-pedagogy. Techno-pedagogy may become an effective means of developing problem solving ability and scientific creativity. The experimental treatment proved the effectiveness of the prepared module for developing problem solving ability and scientific creativity. The developed techno-pedagogical module contributed information on the incorporation of various sources of ICT for the effective transaction of the curriculum. When implemented systematically in real classroom set-ups, it can enhance students' problem solving ability, scientific creativity, and also support positive behaviour. The teachers who are using this module could convincingly improve their teaching-learning process in the classrooms. This attempt will definitely produce worthwhile and responsible citizens who will lead our country to progress.

References

Anboucarassy, B. 2015. Problem Solving Ability of Higher Secondary Students in Relation to their Learning Styles. *International Journal of Applied Research.* 1(7). 127–131.

Babu, R. and T.S. Vimala. 2008. Impact of Multimedia Method in Accounting Learning at Higher Secondary Level. *Journal of Educational Research and Extension.* 45(4). 51–58.

Bala, P. and Kausar Quraish Shaafiu. 2016. Academic Achievement of Secondary School Students in Relation to their Problem Solving Ability and Examination Anxiety. *International Journal of Indian Psychology.* 3(4), 138–154.

Baranisree, C. 2012. *Effectiveness of Video-Based Programme in Teaching Grammar for VII Students in Ramanathapuram (Published Master's Dissertation).* Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore.

Baregama, Shipra and Rita Arora. 2021. A Review of Studies on Techno-pedagogical and Content Competencies. *Elementary Education Online.* 20 (5). 1128–1130. doi:10.17051/ilkonline.2021.05.122

Barron, F. and C. W. Taylor (Eds.). 1963. *Scientific Creativity: Its Recognition and Development.* John Wiley. Oxford, England.

Brausford, J. and B.S. Stein, 1984. *The Ideal Problems Solver: A Guide for Improving Thinking, Learning, and Creativity.* New York.

Belland, B.R. 2009. Using the Theory of Habitus to Move Beyond the Study of Barriers to Technology Integration. *Computers and Education.* 2(3). 16–25.

Bingimlas. 2009. Barriers to the Successful Integration of ICT in Teaching and Learning Environments: A Review of the Literature. *Eurasia Journal of Mathematics, Science and Technology Education.* 2(3). 15–21.

Brysbaert, M. 2019. How Many Participants Do We Have to Include in Properly Powered Experiments? A Tutorial of Power Analysis with Reference Tables. *Journal of Cognition.* 2(1). 16. https://doi.org/10.5334/joc.72.

Chen et al. 2009. Integrating Technology in the Classroom: A Visual Conceptualisation of Teachers' Knowledge, Goals and Beliefs. *Journal of Computer Assisted Learning*. 4(5). 11–19.

Cohen, L., L. Manion and K. Morrison. 2007. *Research Methods in Education*. Routledge.

Cox, S. and C. R. Graham, 2009. Diagramming TPACK in Practice: Using an Elaborated Model of the TPACK Framework to Analyse and Depict Teacher Knowledge. *Tech Trends*. 3(1). 12–18.

D'Zurilla, T. J. 1988. Problem Solving Therapies in K. S. Dobson (Ed.). Handbook of Congitive-behavioural therapies. Guilford Press. 99. 85–135.

Gall, M. D., W. R. Borg. and J. P. Gall. 1996. *Educational Research: An Introduction*. Longman Publishing.

Hu, W. and H. Yun. 2006. The Influence of 'Learn to Think' Activity Curriculum to the Creativities of the Secondary School Students. *Education Science*. 22. 92–94.

Hu, Weiping, Baojun Wu, Xiaojuan (Jessica), Jia, Xinfa Yi, Chunyan Duan, Winter Meyer and James C. Kaufman, 2013. Increasing Students' Scientific Creativity: The 'Learn to Think' Intervention Program. *Journal of Creative Behaviour*. 47. 3–21. doi: 10.1002/jocb.20.

Hu, W. and L. Znang. 2009. The Influence of 'Learn to Think' Activity Curriculum to the Activity and Learning Achievement of Primary School Students. *Education Research and Experiment*, 6, 70-74.

Ishan, M.Z. 2011. Effects of Multimedia-based Instructional Technology on African American Ninth Grade Students' Mastery of Algebra Concepts. Paper presented at the Annual Meeting of the International Political Science Association, Honolulu, Hawaii.

Koehler, M. J. and P. Mishra. 2005. What Happens When Teachers Design Educational Technology? The Development of Technological Pedagogical Content Knowledge. *Journal of Educational Computing Research*. 32(2). 131–152.

Lacken, R. 1964. In Widening Horizons in Creativity, Taylor (Ed.). John Wiley, and Sons. New York.

Li, J. 2010. 'Learn to Think' Activity Curriculum for Puplis Creative Tendency of Impact Study. Master's thesis, Shaanxi Normal University. Linfen, China.

P. Quillo Geraldine and Janneth Q. Rondina. 2021. Techno-Pedagogy: Its Impact on Students' Achievement Scores in Mathematics. *Science International*. Lahore. 33(3). 165–166.

Robertson, S. Ian. 2001. What is a Problem. *Problem Solving*. Psychology Press.

Shabana, A. 2022. *Effect of Techno-pedgogy on Coping Strategies, Study Habits and Academic Performance of Madarsa Students at Secondary Level.* Unpublished Project Report, Maulana Azad National Urdu University.

Sharma, V.P. and J.P. Shukla. 1985. Verbal Test of Scientific Creativity. National Psychological corporation: Agra.

Shulman, L. 1986. Those Who Understand: Knowledge Growth in Teaching. *Educational Researcher*. 15(2). 4–14.

So, H. J. and B. Kim. 2009. Learning about Problem Based Learning: Student Teachers Integrating Technology, Pedagogy and Content Knowledge. *Australasian Journal of Educational Technology*. 25 (1). 101–116.

Sarkar, S., Sanjay Mohapatra and J. Sundarakrishnan. 2017. Assessing Impact of Technology Based Digital Equalizer Programme on Improving Student Learning Outcomes. *Education and Information Technologies*. 22(1). 195–213.

Torrance, E.P. 1962. *Guiding Creative Talent*. Englewood Cliffs. Prentice Hall, Inc. New Jersey.

Wicaksono, Iwan Wasis and M. Madiazim. 2017. The Effectiveness of Virtual Science Teaching Model (VS-TM) to Improve Student's Scientific Creativity and Concept Mastery on Senior High School Physics Subject. *Journal of Baltic Science Education*. 16. 549–561.

Winkler, Rainer, Matthias Sollner and Jan Marco Leimeister. 2021. Enhancing Problem Solving Skills with Smart Personal Assistant Technology. *Computers and Education*. 165. 99–115.

Yildirim, I. H, and O. Sensoy. 2018. Effect of Science Teaching Enriched with Technological Practices on Attitudes of Secondary School 7th Grade Students towards Science Course. *Universal Journal of Educational Research*. 6(5). 947–959.